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claim of a judgment, and the virtuality and vague ulterior reference of a presupposition!

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RECENT STUDIES OF BODILY EFFECTS OF FEAR, RAGE, AND PAIN[1]

DURING the past three years a series of investigations has been carried on in the Harvard Physiological Laboratory with the object of securing further insight into bodily changes accompanying pain and the major emotions. This work was the outgrowth of an interest in the inhibitory effect of pain and emotional excitement on digestive processes. The disturbances of digestion attending these affective states may considerably outlast the period of obvious excitement.[2] What might be the occasion for the continuance of emotional disturbance in the body so long after the emotion-producing object has disappeared?

A suggestion that seemed reasonable was that the state of excitation was continued by secretion of the adrenal glands. These small bodies pour into the blood-stream a substance (adrenin, adrenalin, epinephrin) which exerts on structures innervated by the sympathetic nerves the same effects as are produced by impulses passing along those nerves. Thus the injection of adrenin will cause dilatation of the pupil, erection of hairs, inhibition of the movements of the alimentary canal, and other well-known consequences of sympathetic stimulation. But these glands are themselves stimulated by nerve impulses passing out by sympathetic pathways. It might be, therefore, that the bodily changes accompanying emotional excitement are produced initially by nerve impulses, that these impulses also rouse secretion of the adrenal glands, and that this secretion circulating in the blood continues by chemical influence changes nervously initiated.

By using as an indicator a strip of intestinal muscle, sensitive to adrenin in dilutions 1:20,000,000 parts, we were able to show that when a dog barks at a cat, and the cat reacts by signs of terror or by a raging counter attack, the cat's blood, taken near the opening of the adrenal veins, contains an increased adrenal secretion.[3] Further-more, stimulation in an anesthetized animal of afferent nerves which, if stimulated in the conscious animal would cause pain, likewise evoked an increased secretion from the adrenal glands.[4] Pain, therefore, and such major emotions as fear and rage are accompanied by the discharge of a substance which can cause further excitation of organs innervated by the sympathetic system.

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[1] A summary of remarks made at the meeting of the American Psychological Association, New Haven, December 31, 1913.

[2] See Cannon, "The Mechanical Factors of Digestion," London and New York, 1911, page 217; also *American Journal of the Medical Sciences,* 1909, CXXXVII., page 480.

[3] See Cannon and de la Paz, *American Journal of Physiology,* 1911, XXVIII., page 64.

Certain remarkable effects of injecting adrenin have for many years been known. For example, it will cause liberation of sugar from the liver into the blood to such an extent that the sugar may appear in the urine (glycosuria). It will drive the blood from the abdominal viscera into the heart, lungs, central nervous system, and the limbs. It seems to act as an antidote to muscular fatigue. And it renders more rapid the coagulation of blood. The question at once arose after our first observations, does the adrenal secretion poured out in pain and emotional excitement likewise produce these effects? Our later researches have been concerned with answers to this question.

Emotional excitement and "painful" stimulation were proved to be accompanied by glycosuria. If a caged cat is frightened or made angry by a barking dog it is likely to be glycosuric. Students after a hard examination, and football players after a thrilling contest, also have, in many instances, glycosuria.[5] The mere handling of a rabbit preparatory to an operation may nearly triple the sugar content of its blood.

If a muscle is fatigued, the threshold of irritability rises. It may rise as much as 600 per cent., but the average increase is approximately 200 per cent. If the fatigued muscle is allowed to rest, the former irritability is gradually regained, though two hours may pass before the recovery is complete. If a small dose of adrenalin is injected intravenously, or the adrenal glands are stimulated to secrete, we have found that the former irritability of the fatigued muscle may be recovered within three minutes. In this way adrenal secretion may largely restore efficiency after fatigue.[6]

Fear and anger—as well as worry and distress—are attended, as already stated, by cessation of the contractions of the stomach and intestines. These mental states also reduce or temporarily abolish the secretion of gastric juice. Adrenin injected into the body has the same effect. Besides checking the functions of the alimentary canal, adrenin drives out the blood which, during digestive activity,

[4] See Cannon and Hoskins, *American Journal of Physiology,* 1911, XXIX, page 274.

[5] See Cannon, Shohl, and Wright, *American Journal of Physiology,* 1911, XXIX., page 280; Cannon, *ibid.,* 1914, XXXIII., page 359.

[6] See Cannon and Nice, *American Journal of Physiology,* 1913, XXXII., page 44; Gruber, *ibid.,* 1914, XXXIII., page 354.

floods the abdominal viscera. This blood flows all the more rapidly and abundantly through the heart, the lungs, the central nervous system, and the limbs.[7]

If adrenin is injected in very minute amounts into the blood, the time which intervenes between removal of blood from the vessels and its clotting is greatly reduced. The same hastening of coagulation is observed if splanchnic impulses are excited, or an afferent nerve (*e. g.*, the sciatic) is stimulated in a decerebrate animal, or if the animal is roused to fear or anger. The clotting time which, by the method used, was usually four or five minutes, was in some instances reduced to half a minute.[8]

These profound effects of pain and fear and rage are not in the slightest degree directly subject to voluntary action. They are rather of the nature of reflexes, for they appear promptly, and result from impulses which traverse pathways already prepared in the nervous organization of the individual. Since the effects are reflex in character, and since reflexes are responses commonly useful to the body, it is pertinent to enquire regarding the utility of the changes above described.

The clue which gives these responses significance is found in considering the conditions which would accompany fear or great anger or pain. McDougall has pointed out the relation between these effective states and certain instincts. Thus fear is associated with the instinct to run, anger with the instinct to fight.[9] The emotions in wild life would be roused in the presence of prey or the enemy—a situation that would not unnaturally involve both the pursuer and the pursued in a desperate run or a fight. In case of combat pain would add to the stimulus of the emotion, and thus there might ensue a supreme and prolonged struggle.

Under such circumstances the liberated sugar would be serviceable for the laboring muscles, for it is known to be the elective source of muscular energy. The adrenal secretion, by abolishing the effects of fatigue, would place the muscles unqualifiedly at the disposal of the nervous system. The shifting of the blood from the less insistent viscera of the abdomen to the organs of utmost value in critical physical struggle—the heart, lungs, limbs, and nervous system—would be of the greatest service in assuring efficient action of these organs. And if in the combat the vessels are injured, prompt clotting of the blood might help to prevent dangerous bleeding.

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[7] See Biedl, "Innere Sekretion," Second edition, Leipzig, 1913. Pages 434, 435.

[8] See Cannon and Mendenhall, *American Journal of Physiology*, 1914, XXXIII. *Proceedings of the American Physiological Society*, Dec. 29, 1913.

[9] McDougall, "Introduction to Social Psychology," London, 1908. Pages 49, 59.

The emotional reactions above described may each be interpreted, therefore, as making the organism more efficient in the struggle which fear or rage or pain may involve. And that organism which, with the aid of adrenal secretion, best mobilizes its sugar, lessens its muscular fatigue, sends its blood to the vitally important organs, and provides against serious hemorrhage will stand the best chance of surviving in the struggle for existence.[10]

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REVIEWS AND ABSTRACTS OF LITERATURE

The Scope of Formal Logic. A. T. SHEARMAN. London: University of London Press. 1911. Pp. xiv + 162.

In a previous work, "The Development of Symbolic Logic," Mr. Shearman gave an account of the "older" work of Boole, Venn, Schröder, etc., *i. e.,* of the "pre-Peanesque logicians," as he is pleased to call them. The present volume is, in a way, a continuation of the earlier one. It gives a brief exposition of the logical work of Frege, Peano, and Bertrand Russell. For by "Formal Logic" Mr. Shearman means here what has been variously designated by the names "symbolic logic," "mathematical logic," "algebra of logic," "symbol logic" (Mrs. Ladd-Franklin), "logistic" (Couturat). This kind of logic has not yet found its fitting name; but it is "making history." The purpose of "The Scope of Formal Logic" is to convince the reader of the importance of the work in this field, and, without presupposing any familiarity with the writings of Frege, Peano, Russell, to lead the uninitiated to these fountain-heads of modern logical thought. In the first chapter a number of important terms, such as "propositional function," "variable," etc., are elucidated. In the second chapter Frege's, Peano's, and Russell's symbols, or at least some of the more frequent among them, are explained by translating several propositions, some simple, some more complex, from their symbolic statements into English. This is continued in the third chapter which exhibits the methods of proof in "Formal Logic." Chapter IV. is devoted to a treatment, by means of these symbolic methods, of opposition, conversion, syllogism, etc., *i. e.,* the usual subject-matter of ordinary logic. Chapter V. shows "(1) that arithmetical notions and processes may be replaced by logical notions and processes, (2) that geometrical notions and processes may be similarly replaced, and (3) that general logic *ought,* for scientific purposes, or to enable us to reach conclusions that have always been supported by common sense, to be regarded as lying at the basis of pure mathematics" (p. 130). The remaining two chapters are given over to a "philosophical treatment of number" and of "space." The author has given here more of his own thoughts, though he makes acknowledg-

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[10] For a detailed discussion of the interpretation here outlined see Cannon, *American Journal of Physiology,* 1914, XXXIII., page 356.